**IN THE UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF TEXAS
WACO DIVISION**

NCS MULTISTAGE INC. Plaintiff, vs. NINE ENERGY SERVICE, INC. Defendant.	§ § § § § § § § §	CIVIL ACTION NO. 6:20-cv-00277

**DECLARATION OF JOHN P. RODGERS IN SUPPORT
OF NCS'S OPENING CLAIM CONSTRUCTION BRIEF**

I. INTRODUCTION

1. My name is John P. Rodgers and I am a resident of Fairfield County, Connecticut. I am over 21 years of age and otherwise competent to make this Declaration. I make this Declaration based on facts and matters within my own knowledge and on information provided to me by others, and, if called as a witness, I could and would competently testify to the matters set forth herein.

2. I have been engaged by NCS Multistage Inc. ("Patent Owner") to investigate and opine on certain issues relating to U.S. Patent No. 10,465,445 entitled "CASING FLOAT TOOL" ("the '445 patent") (Ex. A).

3. I have been asked by Patent Owner to offer opinions regarding the '445 patent in support of claim constructions.

4. I am being compensated by Patent Owner at my standard hourly consulting rate of $300 per hour for my time spent on this matter. My compensation is not contingent on the outcome of this case or on the substance of my opinions. I have no financial interest in either party.

5. I reserve the right to supplement my opinions should additional information become available.

II. QUALIFICATIONS & EXPERIENCE

6. I have a B.S.E. in mechanical engineering and materials science and a second major in mathematics from Duke University. I have an M.S. and a Ph.D. from the Massachusetts Institute of Technology ("MIT"), both from the Department of Aeronautics and Astronautics. In my research and academics at MIT, I worked with active material systems and their application to structural actuation and vibration control. Much of the work involved the development of actuation systems for helicopter vibration control and other industrial and defense applications.

7. I am a professional engineer licensed in Texas, North Dakota, and Connecticut and have over seventeen years of experience in the oilfield. I founded and have worked in my engineering consulting business, Starboard Innovations, LLC, since 2000. In the past seventeen years, I have worked on a wide variety of applications across many industries, though the bulk of my work has come in the development of downhole tools. I have developed new mechanical tools and software focused on a variety of different downhole applications. Several of the tools focused on measuring and analyzing the dynamic response of downhole tools and the surrounding wellbore and formation. Other tools that I have developed involved mechanical actuation systems such as firing heads, frac sleeves, cementing sleeves, and plugging devices. One example was a through-tubing bridge plug, designed for high expansion-ratio applications, which is now a product used in the field. Another design involved an autonomous, self-navigating wellbore plug with the option for dissolvable components. I have developed or worked on downhole tool designs for several other applications including: acoustic telemetry, measurement while drilling (MWD), test valves, fracture and cementing sleeves, and wireline fluid sensing. My involvement with many of these development projects included designing, performing engineering analyses and simulations, developing manufacturing processes, building prototypes, running qualification tests, and supporting field trials.

8. More specifically, I have worked to develop a number of downhole tools for Halliburton and other tool manufacturers. I have designed, fabricated, and qualified a subsea landing string navigation tool that aids in the latching of a string of tools to a depth of 10,000 feet and that operates within the BOP. I have designed, qualified, and fabricated a perforation evaluation tool for measuring the dynamic pressures, loads, accelerations, and temperature within the perforating gun string, adjacent to detonating explosives. The qualification testing of these downhole tools includes pressure tests such as leak tests and collapse-rating tests performed within a pressure vessel to pressures up to 30,000 pounds per square inch (psi). Additionally, I have been a lead test engineer for Halliburton for the qualification testing of downhole tools for BP and Shell for high-pressure, high-temperature (HPHT) applications.

9. I have supported numerous field trials including the providing of instrumentation and downhole tool prototypes, forensic examination of equipment returned from the field, and analysis of data collected from the field. I have also directed a number of tests on test wells at Halliburton.

10. I have also developed software products for Halliburton including applications for pre-job analysis, real-time data telemetry, and post-job data presentation and analysis.

11. I am the sole and/or contributing author of over fifteen publications relating to this field. A comprehensive list of publications is in my attached CV. Appendix 1.

12. I am a member of the Society of Petroleum Engineers (SPE) and American Society of Mechanical Engineers (ASME).

13. I have been named as an inventor on over thirty U.S. Patents. A comprehensive list of my patents is contained in my attached CV.

III. MATERIALS CONSIDERED

14. I have considered the following information in connection with my work in this case:

- **Exhibit A:** U.S. Patent No. 10,465,445 ("the '445 patent")
- **Exhibit B:** File History of U.S. Patent No. 10,465,445 ("the '445 file history") (NCS-Airlock_00003805 to NCS-Airlock_00004072)
- **Exhibit C:** U.S. Patent No. 5,479,986 ("Gano") (NCS-Airlock_00004580 to NCE-Airlock_4596)
- **Exhibit D:** Buoyancy Assist Extends Casing Reach in Horizontal Wells, SPE 50680, 1998 ("Rogers") (Nine_0000135 to Nine_0000142)
- **Exhibit E:** Merriam-Webster definition for Hydrostatic Pressure ("Merriam-Webster Pressure") (NCS-Airlock_00004631)
- **Exhibit F:** Schlumberger Oilfield Glossary entry for Hydrostatic Pressure ("Schlumberger Hydrostatic") (NCS-Airlock_00004620 to NCS-Airlock_00004621)
- **Exhibit G:** Schlumberger Oilfield Glossary entry for Float Shoe ("Schlumberger Float Shoe") (NCS-Airlock_00004597)
- **Exhibit H:** PetroWiki.org Float Shoe entry, Society of Petroleum Engineers ("PetroWiki Float Shoe") (NCS-Airlock_00004601 to NCS-Airlock_00004618)
- **Exhibit I:** Wikipedia entry for Float Shoe ("Wikipedia Float Shoe") (NCS-Airlock_00004598 to NCS-Airlock_00004600)
- **Exhibit J:** Wikipedia entry for Archimedes' Principle ("Wikipedia Archimedes") (NCS-Airlock_00004622 to NCS-Airlock_00004630)
- **Exhibit K:** Int'l Patent No. WO 2010/120774 ("Entchev") (NCS-Airlock_00004679 to NCS-Airlock_00004735)
- **Exhibit L:** World Oil, Casing Tables, 2008 ("World Oil") (NCS-Airlock_00004196 to NCS-Airlock_00004248)
- **Exhibit M:** U.S. Patent No. 4,288,082 ("Setterberg") (NCS-Airlock_00004632 to NCS-Airlock_00004643)
- **Exhibit N:** U.S. Patent No. 7,096,948 ("Mosing") (NCS-Airlock_00004560 to NCS-Airlock_00004579)

- **Exhibit O:** U.S. Patent App. No. 2019/0017345 ("Brandsdal") (NCS-Airlock_00004645 to NCS-Airlock_00004665)
- **Exhibit P:** U.S. Patent No. 9,194,209 ("Frazier") (Nine_0000859 to Nine_0000873)
- **Exhibit Q:** Core Design Packers, https://coredesignltd.com/portfolio-3-columns/hangers-packers/sliding-sleeve-packer/ ("Core Design") (NCS-Airlock_00004619)
- **Exhibit R:** PetroWiki.org Packers entry, Society of Petroleum Engineers ("PetroWiki Packers") (NCS-Airlock_00004544 to NCS-Airlock_00004559)
- **Exhibit S:** Fike TB8100 Tech. Bulletin, https://www.fike.com/wp-content/uploads/2019/02/TB8100-ASME-Code-and-Rupture-Discs.pdf ("Fike") (NCS-Airlock_00004249 to NCS-Airlock_00004251)
- **Exhibit T:** Merriam-Webster definition for Specific Gravity ("Merriam-Webster Gravity") (NCS-Airlock_00004195)
- **Exhibit U:** PetroWiki.org Glossary, Specific Gravity ("PetroWiki Gravity") (NCS-Airlock_00004644)
- **Exhibit V:** Parker O-Ring Handbook, ORD 5700, Parker Hannifin Corp., https://www.parkerorings.com ("Parker") (NCS-Airlock_00004252 to NCS-Airlock_00004543)
- File History of U.S. Patent No. 9,593,542 ("the '542 file history")
- File History of U.S. Patent App. No. 15/421,222 ("the '222 application")
- Extended Reach Drilling: Breaking the 10-km Barrier, F. Allen, P. Tooms, G. Conran, B. Lesso, and P. Van de Slijke, Oilfield Review Winter 1997, pp. 32-47 ("Allen") (Nine_0000018 to Nine_0000033)
- The Uses of Buoyancy in Completing High-Drag Horizontal Wellbores, J.L. Hood, M. D. Mueller, M.G. Mims, SPE 23027, 1991. ("Hood")
- U.S. Patent App. No. 2008/0115942 ("Keller")
- U.S. Patent No. 3,831,680 ("Edwards") (Nine_0000422 to Nine_0000431)
- TCO PGR Petition 2020-00077
- TCO PGR Petition 2020-00078 (Nine_0000194 to Nine_0000319)
- TCO drawings 1018-12-00 and 200502
- NCS AirLock drawings
- Nine BreakThru Drawings (Nine_0000001 to Nine_0000012)

- The Four Heads, Pressure Vessel Engineering ("PV Eng")
- Quality Manufacturing, http://qualitymfggroup.com/hemispherical-heads/ ("Quality Mfg")

IV. OPINIONS

A. The Person of Ordinary Skill in the Art ("POSITA")

15. Based on my education and experience in designing and testing downhole tools, it is my opinion that a person of ordinary skill in the field of downhole plugging devices would have a combination of at least one year of practical experience in developing and/or operating downhole plugging devices or barriers as well as an undergraduate level degree in petroleum or mechanical engineering, or at least three years of practical experience in designing and developing downhole plugging devices. The experience should include plugging devices or pressure barriers including at least one of packers, plugs, or other sealing mechanisms that involve hydraulic seals, sliding sleeves, and other common hydraulic components commonly used in downhole tools.

B. Background on Casing Float Operations

16. In order to extract hydrocarbons such as oil and gas that are trapped in the Earth's crust, a wellbore must be created that penetrates down into the ground to reach the layers where the reservoir is located. The first step in the process is to drill the borehole vertically through the various layers of soil, sand, and rock. The borehole is rough and may be unstable and must be cased with steel pipe to protect its integrity and to provide a convenient conduit for transporting tools and materials between the surface and the reservoir below. In a mostly vertical wellbore with little or no deviation, the casing can simply be lowered into the wellbore with gravity pulling it downward. However, running casing into a deviated wellbore that becomes more horizontally inclined is more challenging. Casing float operations are intended to reduce the drag of the casing in the borehole particularly in lateral sections of the well where gravity is

forcing the casing downward against the lower wall. In Fig.1 below, the wellbore shown includes a common deviation profile having a vertical section 130 (**green**), a horizontal section 140 (**pink**), and a heel or bend section 150 (**blue**) in between. Ex. A, Fig. 1. The rupture disc ("RD") assembly 10 (**purple**) is located at the bottom of the vertical section of the wellbore, forming the upper end of the buoyant chamber 120. Ex. A at 4:11-24, Fig. 1. A float shoe 96 (**orange**) is located at the distal end of the casing string, sealing off the end of the buoyant chamber. Ex. A ('445 Patent) at 4:25-26. The interior of the buoyant chamber is typically filled with air in order to provide a buoyant force when submerged in the higher density drilling mud that fills the borehole. *Id.* at 5:27-41.

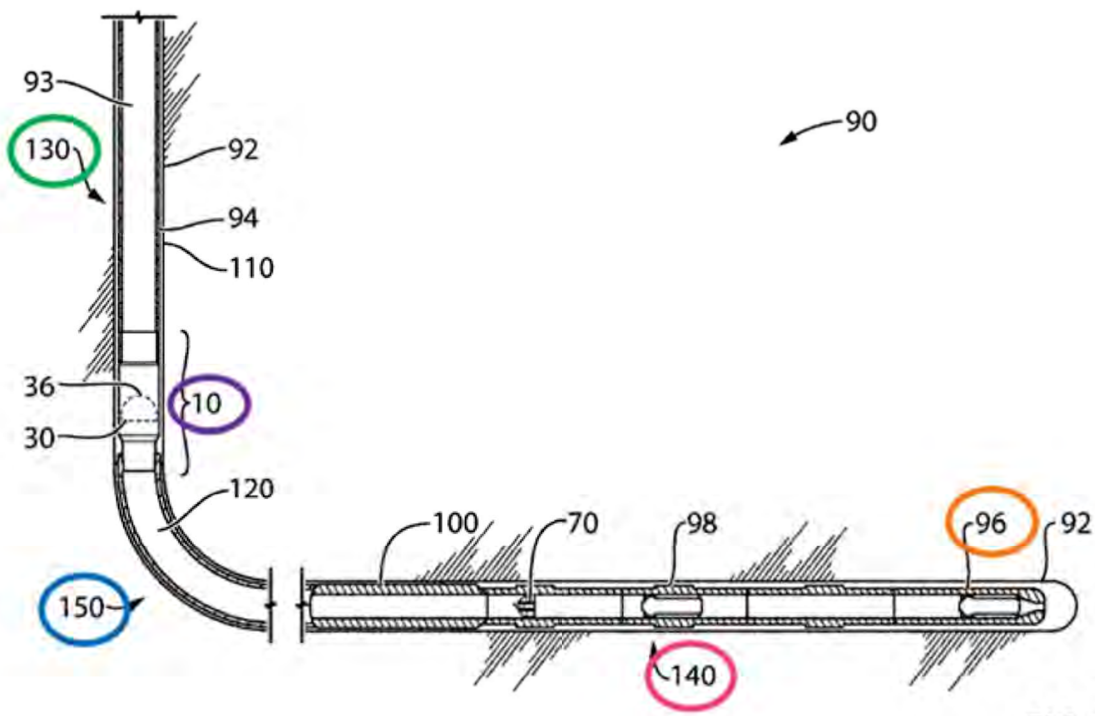


FIG.1

17. I will now describe the process for installing casing. After the wellbore is drilled, the casing string is run into the borehole. At first, the wellbore is vertical and the casing can easily move downward with the weight of the casing providing the force to maintain motion. Note that

no downward force is applied by the rig on the surface—all the force is provided by gravity and the weight of the components in the casing string, including the weight of the casing string or pipe, connectors and fluid inside the pipe. When the bottom of the casing string reaches the bend section 150, the casing begins to engage the borehole rock as the casing bends and more significantly, the downward acceleration of gravity acts to push the steel pipe against the bottom side of the borehole. The contact creates friction which acts as a drag or resistance on the motion of the casing. At some point, as the casing string continues to be pushed down and laterally, the drag on the casing in the horizontal section will match the downward force pushing on the casing, causing the casing to stop moving. The downward force pushing the casing is limited as it only comes from the weight of the casing and fluid inside the casing in the primarily vertical section of the wellbore. Friction limits how far the casing can be run and how far the wellbore can safely be extended to reach additional hydrocarbons without additional pressure being applied. Extending the reach of the lateral section has long been a major goal in the industry in its continual effort to minimize the cost to reach production. One solution has been adding a buoyant chamber which reduces the frictional force or drag and allows the casing string to be run out a longer distance in the horizontal section of the borehole.

18. In order to be useful, the buoyant chamber created in a casing float system does not have to fully overcome the weight of the casing such that it would truly float on the surface of the wellbore fluid[1]. *See* Ex. A ('445 Patent), 5:36-41. It is sufficient to create an upward buoyant force that counters enough of the drag between the casing and the bottom side of the borehole to allow the casing to reach the desired horizonal location. Once the casing is in position, the seal at the top of the chamber is breached and the air inside is allowed to escape, flooding the chamber

[1] The casing is considered neutrally buoyant if it is able to hold a stable position in the surrounding fluid without rising or sinking.

with the wellbore fluid and eliminating the buoyancy. With the inside of the casing reopened, the well completion process can continue to pump fluids down the bore or to run other tools through the bore as required. Typically, cementing of the casing is the next step, where cement is pumped down the casing and through the float shoe at the end to flow back up the annulus around the casing, locking it in to the borehole. The float shoe has a one-way valve that allows for cement to be pumped out while preventing backflow into the casing.

i. Prior Art on Casing Flotation

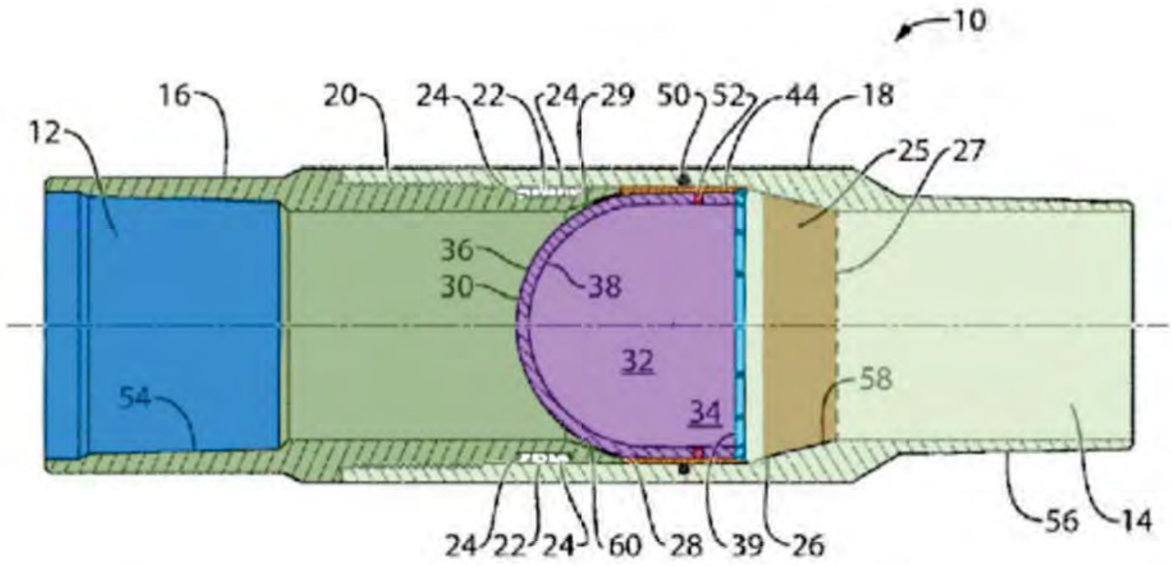
19. Prior art approaches to casing flotation created a buoyant chamber to both reduce hook loads on the rig derrick and reduce the friction on the casing as with the current designs. Many of the prior art methods suffered from some critical drawbacks. First, many required significant effort to remove the barrier at the top of the chamber such as by drilling or milling, or by running a tool into the well to physically retrieve the barrier. Ex. D (Rogers) at Nine_0000136. This was a costly and time-consuming process requiring hours of rig time. Rupture disc ("RD") designs were developed to make the removal process easier. However, these required a specialized piercing tool or spear to break the RD. The tool had to be run down into the well to do the job in a separate intervention step. Alternately, a heavy drop bar could be dropped to impact the rupture disc within the vertical section of the casing. Either way, the piercing tool would have to be removed from the wellbore after it was used. Any intervention step requires significant well time and cost and is undesirable. More recent prior art designs eliminated the intervention step but had other issues, such as leaving a reduced diameter region in the casing at the location of the rupture disc and/or large pieces of debris from the rupture disc that could become obstructions or otherwise interfere with subsequent operations. Ex A, 1:47-49, 2:35-36.

20. The NCS rupture disc design overcomes all of these disadvantages in a simple and efficient design. First, the rupture disc can be shattered by the application of pressure alone with

no intervention needed. Second, the full bore of the casing is restored after the rupture disc is removed. Third, the rupture disc is broken into small pieces. In the NCS design, the acceleration of the RD results in a relative velocity between the RD and the impact surface. Ex. A ('445 Patent) at 2:3-30, 10:3-11. This velocity results in momentum and kinetic energy in the moving RD which is then released upon impact, aiding in the fragmentation of the RD. Having smaller fragments reduces the potential problems that the debris may cause for further downhole operations.

C. The NCS Casing Float Tool

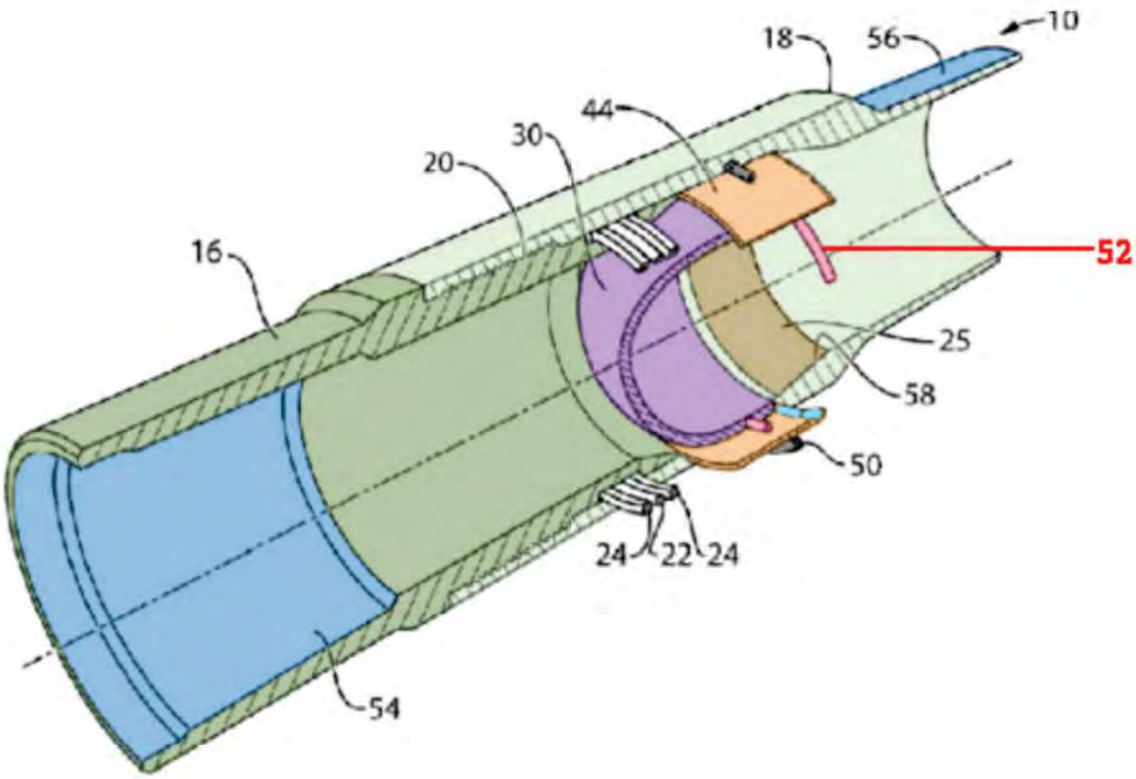
21. An embodiment of the NCS casing float tool described in the '445 Patent consists of a largely hemispherical rupture disc that is sealed in position within a casing string in order to create the top boundary of a buoyant chamber. Ex. A ('445 Patent) at 4:19-24. Referring to Fig. 2 below from the patent, the rupture disc 30 (**purple**) is attached in an initial position in which it is both secured against motion and sealed to the tubular wall. Downhole motion (to the right in the figure below) is restrained by the shear ring 44 (**orange**). *Id.* at 8:44-50. The assembly is held within a larger diameter region of the lower tubular member 18 (**lt. green**), with respect to the nominal casing inside diameter (ID) above and below, and is captured in place by upper tubular member 16 (**dark green**). *Id.* at 7:31-38, 8:30-31. The enlarged bore enables the full nominal flow bore to be realized after removal of the rupture disc 30 at the end of the casing float operation. *Id.* at 7:5-9. Inner o-ring 52 (**pink**) provides a seal between the rupture disc 30 and the shear ring 44 and also provides radial support to rupture disc 30, centralizing it within the bore. *Id.* at 8:44-62, 9:18-19. Outer o-ring 50 (**black**) provides a seal between shear ring 44 and lower tubular member 18. *Id.* at 9:14-17.

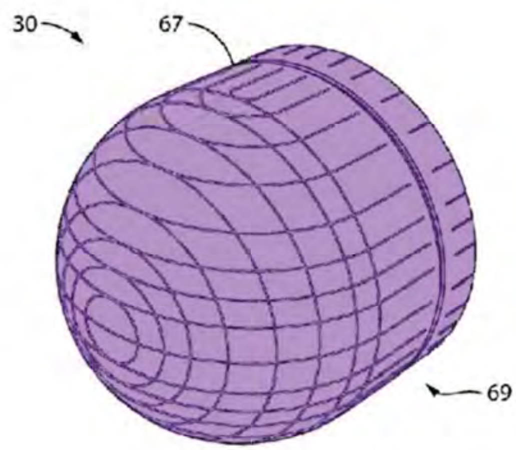


22. Fig. 3 from the patent reproduced below provides a three-dimensional perspective view of the tool. From this perspective, the hemispherical rupture disc 30 (**purple**) can be seen as it is secured and sealed within shear ring 44 (**orange**). The rupture disc 30 is hemispherical on the uphole end but continuously transitions to a cylindrical cross section as it enters shear ring 44, visible in Fig. 3 and also in Fig. 5, also included below. Ex. A ('445 Patent) at 8:11-15. O-ring 50 and o-ring 52 are positioned in the annular gaps between the concentric cylindrical surfaces in order to completely seal across the ID of lower tubular member 18[2]. 9:26-31. An additional o-ring 22 and back-up seals 24 are positioned between the upper tubular member 16 and lower tubular member 18 to prevent any leakage between the inside and outside of the casing string. *Id.* at 7:47-50. Back-up seals 24 are harder rings that protect the o-ring 22 from extruding into the gaps between the mating tubulars to ensure a reliable seal at high differential pressures. The upper end of the upper tubular member includes a female threaded connection on surface 54 (**dark blue**) and the lower end of lower tubular member includes a male threaded connection on

[2] Note that inner o-ring 52 is improperly labeled in the original Fig. 3 and is corrected in the figure below in **red**. In the original Fig. 3, label '52' is incorrectly pointing to outer o-ring 50.

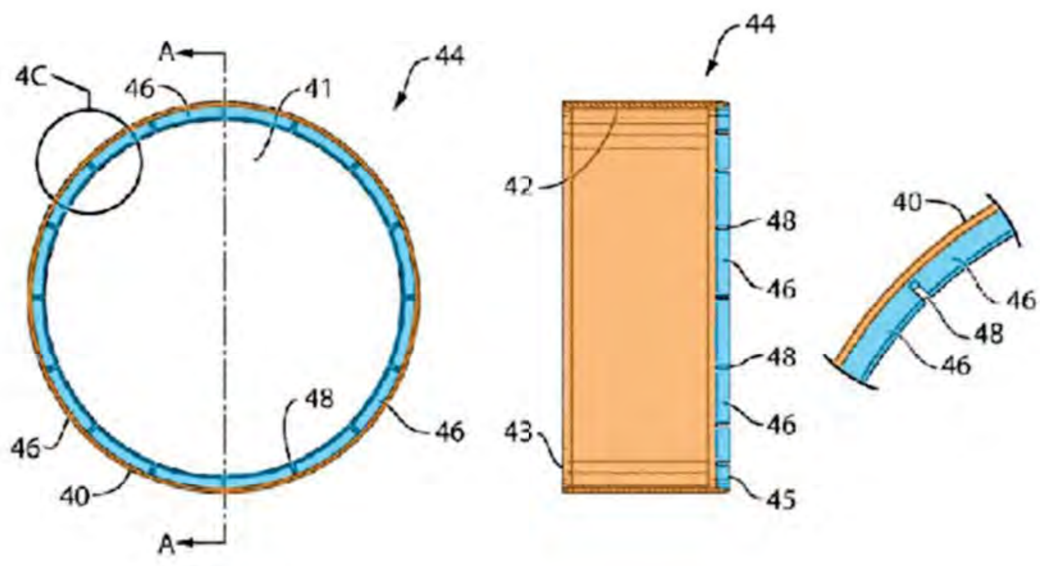
surface 56 (**dark blue**) for integrating the tool between casing joints. *Id.* at 7:60-64.





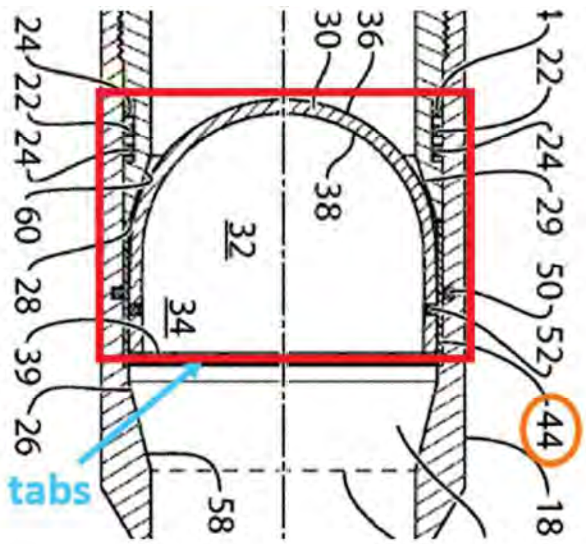
23. An embodiment of shear ring 44 is better displayed in Figs. 4A, 4B, and 4C from the patent, reproduced below. The bottom edge of shear ring 44 has an array of equally sized and distributed tabs 46 (**light blue**) that extend radially inward from the otherwise tubular shape of shear ring 44. *Id.* at 9:56-60. Because the tabs form a segmented ring of smaller diameter, the

array forms a ledge of support or seat for rupture disc 30 that can resist motion in a downhole direction. Shear ring 44 is supported against downhole motion by the chamfered or tapered-diameter surface 58 (**brown**) of lower tubular member 18. The tabs are designed to fail either by shearing off or bending out of the way at a designated axial force level. *Id*. at 9:56-60. The segmented tabs provide an opportunity to adjust the geometry of the tabs to tune the axial force at which the tabs will shear off of the ring to meet varying requirements. Because the shear ring/tabs are relatively flexible as compared to the hard brittle material of the RD, it is primarily the root of the tabs, defined by the largest diameter circle of contact between the RD and the tabs, where most of the load will be carried. *Id*. at 10:54-58. The further inward that the load is applied to the tabs (away from the attachment to the shear ring 44), the less support is given to restraining the RD because the tabs get easier to bend due to the increasing bending moment.



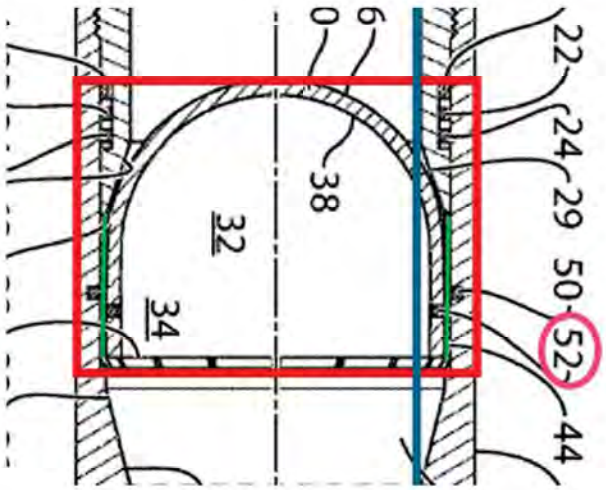
24. In the figure below, Fig. 2 from the patent is cropped and then highlighted to show a red box around the initial position of the rupture disc where it is secured and sealed to the lower tubular. This is the position in which rupture disc assembly 10 is assembled in the casing string

as it is run into the wellbore, moving down along the borehole until reaching a desired depth, or reaching the maximum achievable measured depth (MD). Measured depth is the distance from the surface to a position in the well measured along the path of the borehole. As discussed above, the tabs 46 on the bottom edge of shear ring 44 limit the downward motion of the rupture disc 30 and the o-ring seal 52 on the inside of shear ring 44 provides a centralizing, radial constraint on the rupture disc 30. Thus, the rupture disc 30 will remain within the red outline until the tabs 46 shear, disengaging the rupture disc 30.



25. In the figure below, Fig. 2 from the patent is again cropped and highlighted. In addition to the red box highlighting the initial position of the rupture disc where it is attached, a **blue** line has been added to illustrate the nominal measure of the inside diameter of the casing string continuing uphole and downhole of the device. The **green** line indicates the inside diameter of the tubular member where the rupture disc is secured and sealed. The rupture disc must be secured laterally and sealed along the interface highlighted by the **green** line. In three dimensions, the green line is representative of a cylindrical surface on the ID of the shear ring just as the **blue** line is representative of the cylindrical ID of the casing string. In this two-dimensional representation, the side of the cylinder is represented by a simple line. Also, in this

two-dimensional image, the **blue** line is parallel to the green line. In three dimensions, this means that the axis of the cylinder of the casing ID is parallel to the axis of the cylinder of the tubular member within the red box or region of attachment. Essentially one cylinder must be aligned with the other, or equivalently, the side walls of the two cylinders are parallel when viewed in cross section. The cylinder indicated by the **green** line is larger in diameter. Thus, the cylinder indicated by the **blue** line could fit inside the cylinder indicated by the **green** line.



26. In downhole operations, the rupture disc assembly is designed to maintain a seal at the top end of the buoyant chamber 120 as hydrostatic pressure builds from above. As the casing string is run into the wellbore, it is filled with liquid, often drilling mud, and the column of fluid above the rupture disc increases. Ex. A ('445 Patent) at 4:67-5:3. The total vertical depth (TVD) is a measure of the true vertical component of depth at a position in the wellbore. If the casing is filled with liquid from the rupture disc to the surface, the TVD of the rupture disc in the wellbore along with the density of the liquid will determine the hydrostatic pressure acting on the uphole side of the rupture disc. The downhole side of the rupture disc is acted on by the air or other fluid that fills the buoyant chamber and is generally close to atmospheric pressure. The differential pressure acting on the rupture disc is the difference between the uphole-side pressure in the fluid

and the atmospheric pressure on the downhole side.

27. Once the casing has been pushed or "floated" to the target depth in the wellbore, the buoyant chamber is no longer needed and the rupture disc can be ruptured to complete the landing of the casing. To do this, a pump at the surface is used to apply pressure to the fluid in the casing, raising the pressure on the uphole side of the rupture disc. The pressure increases until the disengaging pressure is reached. *Id.* at 9:63-10:11. This is the pressure at which the shear ring fails, allowing the rupture disc to move in a downhole direction. During this motion, the seal is maintained by inner o-ring 52 so that the pressure continues to act to accelerate the rupture disc. Thus, the rupture disc will attain a velocity in the downhole direction that carries it to impact surface 58, which has a tapering or narrowing diameter such that the rupture disc is forced to contact it. *Id.* at 11:27-41. The force of the impact along the bottom edge of the rupture disc causes it to rupture and further shatter into many small pieces.

28. As an example, consider the following pressures which may be used in the design of the casing float tool. The hydrostatic pressure of the fluid above the rupture disc when it is positioned in the wellbore may be 1,000 psi. This is the pressure due to the column of drilling mud acting on the surface of the disc. *Id.* at 4:67-5:3. The rupture disc may have a rated rupture burst pressure of 10,000 psi. Ex. A ('445 Patent) at 6:21-23. This means that in the absence of other forces acting besides hydraulic pressure, it will require 10,000 psi to cause failure and rupture of the rupture disc. Finally, the disengaging pressure must be set between these two pressures so that the disc moves before rupturing from the pressure of the fluid. For example, the disengaging pressure may be set to 3,000 psi by design of the tabs of the shear ring. *Id.* at 9:60-63. In operation, the pressure will rise to 1,000 psi as the rupture disc and casing move down into the wellbore. The pump will raise the pressure to 3,000 psi (1,000 psi hydrostatic plus 2,000 psi applied pump pressure) to shear the tabs and disengage the rupture disc. The rupture disc will

accelerate downhole and will impact the lower tubular to break or rupture, opening up the full casing ID. *Id.* at 11:27-41. In operation, the rupture disc will never experience the 10,000 psi required to directly rupture it by hydraulic pressure alone. *Id.* at 9:63-67, 11:45-58, 13:27-39. A major advantage of the design is that the disengaging pressure can be set relatively low to protect the casing from excessively high activation pressures that could cause damage. *Id.* at 11:27-29.

29. The reason that the rupture burst pressure is designed to be significantly higher than the disengaging pressure is two-fold. First, the pressure needed to eliminate the seal and open the buoyant chamber needs to be substantially lower than the maximum allowable pressure that the casing itself can withstand without damage, such as a burst of the casing itself. *Id.* at 11:8-19. Second, in order to take advantage of the disengage-and-accelerate design of the device, the rupture burst pressure for the disc needs to be set substantially higher than the disengagement pressure so that it does not unintentionally fail during the trip down into the well. During that trip, the casing is subjected to vibrations and shocks as it pushes down through the rock. Additionally, the fluid pressure acting on the disc may not be steady, as the motion of the casing string introduces pressure dynamics and are superposed on the hydrostatic pressure. For these reasons, some margin is required to make sure the relatively brittle rupture disc does not fail prematurely.

30. The cylindrical surface of rupture disc, visible in Fig. 5 below from the patent, is a design feature that enables both the robust seal design and the simple support mechanism on the segmented ring of tabs 46. The cylindrical surface on the outside diameter (OD) of the shear ring provides the ideal seal engagement surface for a component that is intended to slide axially and is the most common seal geometry found in downhole tools.

31. Since the bottom edge of the rupture disc lies in a plane that is perpendicular to the axis of the tubular, it can be supported with a purely axially-oriented contact force from shear tabs 46.

This contact force direction ensures that the stresses in the side walls of rupture disc 30 remain purely compressive, which maximizes the effective strength of the device and thus maximizes the rupture burst pressure rating for a given rupture disc thickness and material selection. *Id.* at 10:64-11:7.

D. Definitions and Background

i. Hydrostatic Pressure

32. "Hydrostatic pressure" refers to the pressure developed by a column of fluid above a measurement point as a result of the density of that column of fluid and the acceleration of gravity. Ex. E (Merriam-Webster Pressure) at NCS-Airlock_00004631; Ex. F (Schlumberger Hydrostatic) at NCS-Airlock_00004620. Only the total vertical depth (TVD) and the density of the fluid affect the hydrostatic pressure at a given point in the wellbore. Ex. A ('445 Patent) at 6:19-21, 13:27-35. If the density of the fluid varies along the casing length, then the density distribution must be considered.

ii. Float Shoe

33. A "float shoe" is a device placed on the end of a casing string to provide a seal against wellbore fluid coming into the casing. *Id.* at 4:19-26; Ex. G (Schlumberger Float Shoe) at 1; Ex. H (PetroWiki Float Shoe) at NCS-Airlock_00004602 to NCS-Airlock_00004603; Ex. I (Wikipedia Float Shoe) at NCS-Airlock_00004599. The float shoe also contains a one-way valve that allows for cement to be pumped downhole through the shoe and into the borehole. The valve is set to open at a designated differential pressure. Ex. A ('445 Patent) at 4:37-40.

iii. Buoyant Force

34. The "buoyant force" arises from Archimedes' Principle, that the upward force on an object emersed in a fluid is equal to the weight of the displaced fluid. Ex. J (Wikipedia Archimedes) at NCS-Airlock_00004622. The weight of the displaced fluid depends upon the

density of the fluid surrounding the object. Ex. A ('445 Patent) at 5:27-48. The term "buoyant" refers to an object immersed in a fluid having a reduced effective weight as a result of a buoyant force counteracting the gravitational force.

iv. Upper/Lower

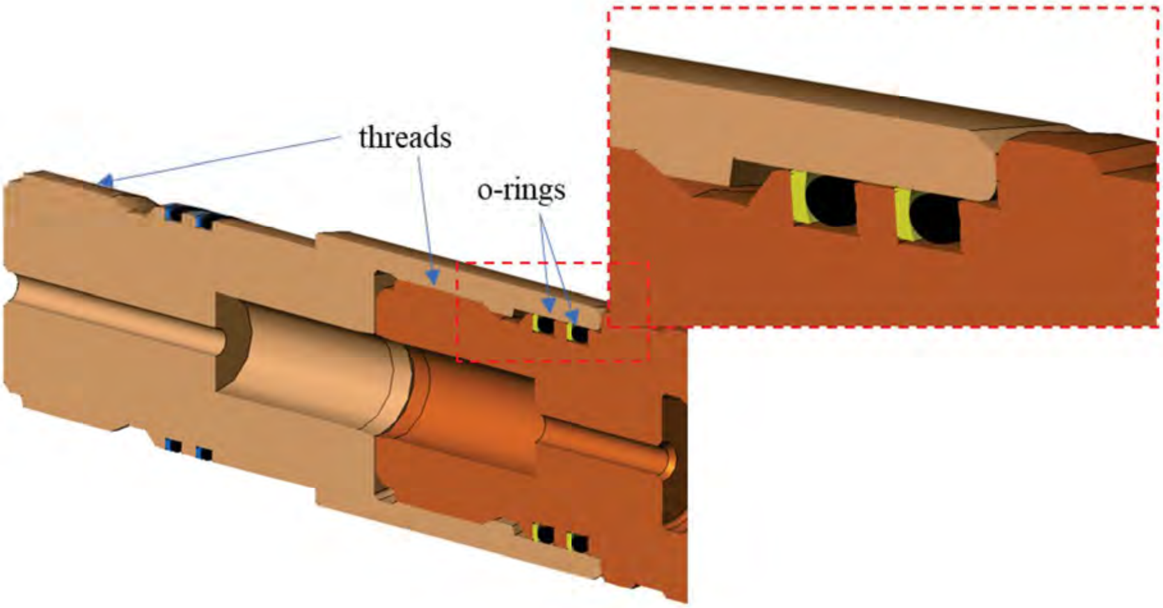
35. In the downhole or wellbore environment, the term 'uphole' refers to the direction within the wellbore towards the surface. The term 'downhole' refers to the direction within the wellbore that is toward the bottom of the well. With reference to any component within the wellbore, the terms 'upper' and 'lower' will refer to the general positions relative to the surface, also described by 'uphole' and 'downhole' directions. *Id*. at 3:63-4:4.

v. Sealing Engagement

36. "Sealing engagement" means a hydraulic seal between two components that can be achieved by direct or indirect means and may be achieved through an intermediate component. In a direct sealing engagement, the rupture disc may seal directly to the bore of the tubular. *Id*. at 8:4-7, 19-31. For example, a sealing engagement may be achieved using an elastomer such as an o-ring between two components sized so create a very narrow annular gap between the parts. Sealing engagement may also be achieved through intermediate components such as a shear ring with elastomer seals on both sides, and as shown in Figs. 2 and 3 of the patent. *Id*. at 9:26-31.

37. Seals are commonly used between components of downhole tools to create a sealing engagement between surfaces. The most common example is that of a piston in a seal bore. A piston is generally a solid cylindrical component which will have one or more o-ring glands machined in the outer cylindrical surface to house an o-ring. The mating seal bore is a cylindrical hollow space within an outer housing sized to fit the particular o-ring. The piston diameter, the gland dimensions, and the seal bore are all precisely designed and fabricated to properly squeeze and contain the o-ring so that it maintains a seal and is not damaged during assembly or

operation. A common example of this type of seal is illustrated in the CAD model from a downhole tool shown below (created by me), with the seal region enlarged in the upper right. In this example, male (pin connection) and female (box connection) threads are used to couple the two subs and a pair of o-rings is used to provide a seal to prevent wellbore fluid from leaking into the interior of the tool. The yellow components are back-up rings used to prevent extrusion of the o-ring elastomer into the small gap between the mating parts. The male component houses the o-rings in grooves called glands and the female part has a seal bore. Alternately, the o-ring glands could be positioned in the female component to achieve the equivalent seal.



38. O-ring seals in downhole tools are designed to be fluid-tight. However, it is not uncommon for seals to develop small leaks while still serving their intended purpose. Thus, a POSITA would understand that a fluid-tight seal may not be 100% perfect in operation. For example, a seal may become leaky as a result of corrosion or wear occurring on sealing surfaces, debris accumulating between surfaces, or damage happening to the o-ring. The term 'substantially fluid tight seal' is indicative of the desire to have a perfect seal in light of the

reality of some leakage occurring in practice.

39. In order to maintain the integrity of a buoyant chamber within the casing, a seal is required to substantially prevent fluid leakage around a barrier, e.g. rupture disc, as a result of differential pressure. If substantial leakage occurs, more dense fluids can flow into the chamber eliminating the buoyancy. In order to maintain a seal, the position of the barrier must be held in a relatively fixed position in the casing. It is difficult to maintain a seal on a component that moves beyond a very limited range of travel.

vi. Disengaging Pressure

40. The term "disengaging pressure" in the context of the '445 Patent, includes a pressure that causes the disc, before rupturing, to move in a downhole direction away from the point of initial attachment. *Id.* at 9:63-10:11.

vii. Internal Diameter

41. The term "internal diameter" or ID is commonly used in the oilfield industry. Its meaning can vary based on the context in which it is used. One meaning is the interior cylindrical surface of the casing. The specification of the '445 Patent uses that term in the same way: "Once the disc has been ruptured, the **inside diameter** of the casing string in the region of the rupture disc assembly **10** is substantially the same as that in the remainder of the casing string (e.g. casing ID (inner diameter) is restored following rupture of the disc)". *Id.* at 6:62-66 (emphasis added). "The shattering of rupture disc **30** results in opening of passageway **14** of lower tubular member **18,** so that the casing **internal diameter** in that 50 region of lower tubular member may be restored to substantially the same diameter as the rest of the casing string (e.g. the casing string above and below the tubular or region in which the rupture disc was installed)." *Id.* at 10:47-53 (emphasis added).

42. Extrinsic evidence supports that meaning. Ex. K (Entchev) at [0019], [0021], [0031], [0080], [0083], [0087], [0095], [0102], [0108], [0110], [0134], [0143], and [0144]; Ex. L (World Oil) at NCS-Airlock_00004196; Ex. M (Setterberg) at 4:3-34, 4:40-46, 5:18-20, 5:36-38, 5:59-64, 6:3-8, 6:9-16, 7:12-15, 7:19-23, 7:26-28, 7:40-44, 7:66-68, claim 15; Ex. N (Mosing) at Abstract, 1:36-40, 2:21-24, 3:2-5, 3:13-16, 3:20-24, 3:44-48, 4:26-29, 5:14-17, 5:48-53, 5:57-62, 11:18-21, 13:21-24, 13:28-30, 15:55-57; Ex. O (Brandsdal) at [0068]; Ex. P (Frazier) at 5:5-12, 7:38-40, 10:31-34, claims 1, 7; Ex. Q (Core Design) at NCS-Airlock_00004619; Ex. R (PetroWiki Packers) at NCS-Airlock_00004545. Inner diameter, internal diameter, inside diameter, and ID are all synonymous in oilfield terminology.

43. ID or internal diameter can also refer to a length measurement of the diameter of a circular cross-section cut perpendicular to the axis of the inside of a component of the casing. Measurements of the ID can vary due to manufacturing irregularities and deformation of the tubular wall. A nominal ID is typically described as the average expected diameter. One of skill in the art can readily determine how "ID" or "internal diameter" is being used based in the context of the usage.

viii. Attached

44. The term 'attached' as used in the context of the specification refers to a relationship between an RD and a surface to which the rupture disc is directly sealed and secured. "The rupture disc is secured above or within the lower tubular member" and "the securing mechanism generally provides a convenient means to fluidically seal the rupture disc within the casing string." Ex. A ('445 Patent) at 2:54-55, 2:59-61. "The fluid exerts force on the convex side **36** of rupture disc **30**, and on a securing mechanism holding the rupture disc in place, as discussed in further detail hereinbelow. The force is sufficient to overcome the engagement function of the securing mechanism, causing the disc to suddenly move downward." *Id*. at 6:28-33.

ix. Cylindrical Surface

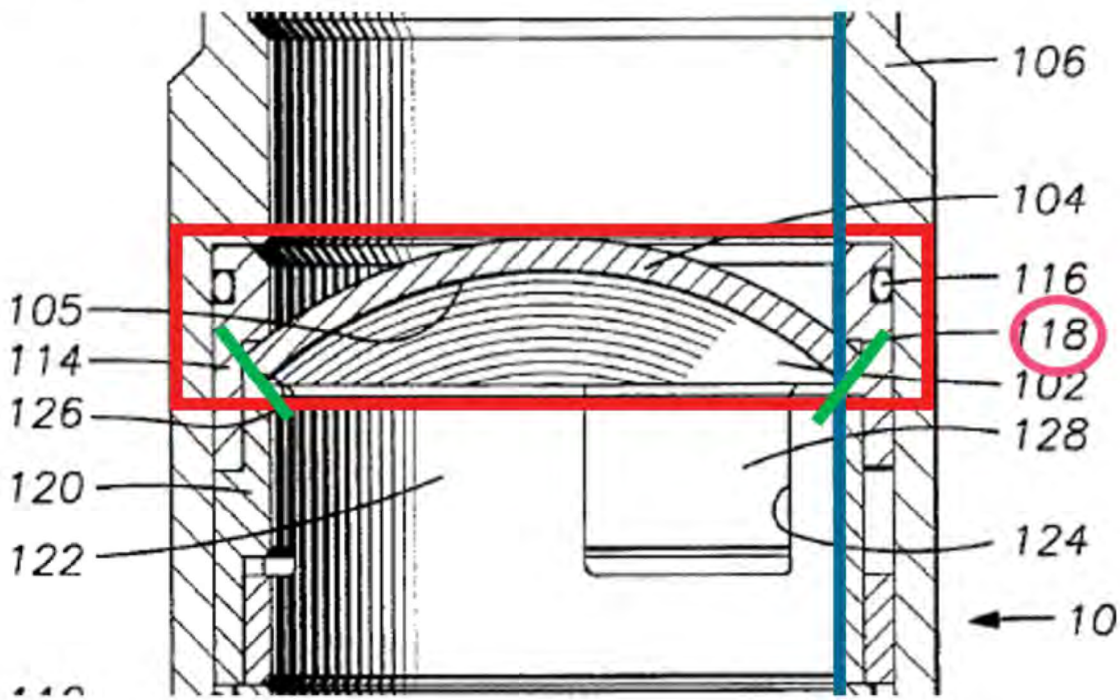
45. The term 'cylindrical surface' in the context of downhole tools, and in reference to the surfaces of the casing string, refers to the interior (or exterior) surface of a largely cylindrical tubular or pipe structure. As long as the pipe is straight and generally circular in cross section, the surfaces will be cylindrical. *Id*. at 8:44-46.

x. Parallel to and Larger than the Internal Diameter

46. The term "larger than the internal diameter" means that the surface of the tubular where the disc is attached is a cylinder that is wider than the casing string, like a wider cylinder stacked on top of a narrower cylinder. "Hemispherical portion **32** is continuous with cylindrical portion **34** which terminates in a circumferential edge **39** 'having a diameter that is similar to the inner diameter of the radially expanded region **25** of lower tubular member **18** at shoulder **26**." *Id*. at 8:11-15. This "radially expanded region" is a cylindrical region of the tubular having a larger diameter than the casing above and below. This is further explained in detail in the '445 prosecution history in arguments regarding the prior art of Rogers and Gano. Ex. B ('445 file history) at NCS-Airlock_00003869-70. With reference to the applicant's argument, the Examiner references, "wherein the inner diameter of the tubular member where the rupture disk attaches is larger than the inner diameter of the casing string". The claims were amended to require "a rupture disk attached to a tubular member at a location having a diameter that is larger than the internal diameter of the casing string". Ex. B ('445 file history) at NCS-Airlock_00003843-44.

47. The term "parallel to the internal diameter of the casing string" means that the surface of the tubular where the disc is attached is a cylinder that is parallel to the inner surface of the casing string, like a cylinder stacked on top of (or nested within) another cylinder having a parallel central axis. "Rupture disc **30** may be … concentrically disposed traverse to the longitudinal axis of the upper and lower tubular members." Ex. A ('445 Patent) at 8:4-7. This

describes the arrangement between the cylindrical outer surface of the RD relative to the cylindrical ID of the casing. Both are cylindrical and are concentric. Concentric means that the central axes of the cylinders is coincident, which further means that the axes must also be parallel. The prosecution history also provides additional guidance on the terms, particularly with regard to prior art Gano. Claims were modified to avoid Gano by requiring attachment of the RD in "a region of a tubular member that is not parallel to the internal diameter of the casing string but is instead sloped." Ex. B ('445 file history) at NCS-Airlock_00003843-44. The use of the term "sloped" in contrast to "parallel" indicates, from a two-dimensional cross-section perspective, that the walls of the tubular are either conical or cylindrical, respectively. The sloped surfaces are visible in Fig. 3 from Gano below, highlighted with the green line. The requirement to be parallel, i.e. cylindrical, distinguishes the claimed design from the prior art which had sloped sides.



Ex. C (Gano) at NCS-Airlock_00004585.

xi. Rupture Burst Pressure and Rupturing Force

48. A "rupture disc" is a commonly-used device in the oil industry and with pressure vessels that is designed to fail or rupture at a prescribed differential pressure. Ex. S (Fike) at NCS-Airlock_00004249. In the '445 Patent, the rupture burst pressure is the point at which the RD will fail due to hydraulic pressure alone. Ex. A ('445 Patent), 3:1-3, 4:60-64, 11:8-13. As illustrated in the sample calculation, the minimum rupture burst pressure rating must be designed to be greater than the hydrostatic pressure plus 500 psi margin. *Id.* at 13:27-39. This means that the rupture disc will not fail under an applied pressure less than that minimum. "The hydrostatic pressure during run-in must be less than the rupture burst pressure of rupture disc 30, to prevent premature rupture of the disc" and the "pressure rating" may be 10,000 to 30,000 psi. *Id.* at 6:19-23. The rupture pressure is defined for a static, uniformly applied, differential pressure acting across the RD.

49. The RD used in running casing is not intended to fail via exceeding the rupture burst pressure. Instead, the design relies on a combination of applied pressure and an impact force to shatter the RD, once the disengaging pressure is exceeded. *Id.* at 2:8-9, 7:17-20, 10:3-11. The hydraulic pressure is used to disengage from the securing mechanism and to then to drive the RD toward impact. The impact force can cause a local failure of the RD material that initiates a rupture or shattering in the case of a brittle material. The term "rupturing force" refers to either a hydraulic pressure or impact force that can be used to break or rupture the RD.

xii. Specific Gravity

50. "Specific gravity" refers to the relative density of a material to a reference material. Ex. T (Merriam-Webster Gravity); Ex. U (PetroWiki Gravity). For liquids, the reference material is typically fresh water. If one fluid has a lower specific gravity than another fluid, then it is less dense than that fluid. For example, a specific gravity of a liquid is typically measured with

respect to water. Thus, the specific gravity of well fluid in a wellbore is simply the ratio of the density of the well fluid to the density of water.

Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct.

Date: 10/30/2020

John P. Rodgers

Appendix 1 to Declaration

JOHN P. RODGERS, Ph.D., P.E.

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EDUCATION

Massachusetts Institute of Technology
Cambridge, Massachusetts
Department of Aeronautics and Astronautics

-Ph.D. received October 1998.
Major in Structures Technology and Minor in Estimation and Control.
Thesis Title: *Development of an Integral Twist-Actuated Rotor Blade for Individual Blade Control.*

-Master of Science received May 1995.
Thesis Title: *Modeling and Manufacturing of Adaptive Composite Plates Incorporating Piezoelectric Fiber Composite Plies.*

Duke University
Durham, North Carolina
Department of Mechanical Engineering and Material Science

-Bachelor of Science in Engineering received December 1992.
Graduation with Departmental Distinction
Scholarship Recipient, National Academy for the Advancement of Nuclear Power
-Second major in Mathematics.

AREAS OF EXPERTISE

Knowledgeable in a variety of fields related to mechanical, materials, and aerospace, and downhole engineering, including:

- Structural design and analysis
- Actuation and sensing
- Vibration and noise
- Smart materials
- Manufacturing and QC
- Fluid mechanics and dynamics
- Downhole tool design and test
- Forensic engineering
- Electromagnetics
- Aerodynamics and aeroelasticity
- Structural dynamics
- Active control systems
- Polymer-matrix composites
- Crash/shock survival
- Heat transfer
- Testing and characterization of materials, devices, systems
- Machine design
- Intellectual property
- Instrumentation and sensing

EXPERIENCE

Starboard Innovations, LLC, *President, Founder*
Ridgefield, CT
March 2000-present
Engineering consulting company specializing in concept development, new technology research, design, analysis, prototyping, and testing. Recent projects include:

- Development of multiple downhole oilfield tools and integration of new technologies including sensing, autonomous positioning, explosives safety, acoustic telemetry, remote power generation, vibration mitigation; multi-disciplinary FEA, electromagnetic design; support for field testing and operations; qualification testing for thermal, pressure, shock, explosive operations; strength analysis, damage prediction, and troubleshooting of mechanical systems.
- Development of shock simulation software package and shock sensing downhole tool for predicting, measuring, and optimizing perforating gun string and wellbore dynamics. Prediction of tool string failure under operational loading.
- Led multiple failure investigation teams that included extensive simulations and tests to demonstrate causation; successful in reducing client liability in negotiations. Rapid redesign of deficient design elements to enable a return to reliable service.
- Development and implementation of food production engineering systems for major snack food manufacturer.
- Support for large-scale power grid energy storage system design and installation.
- Litigation support and expert witness for plaintiff and defense involving trade secret, product liability, personal injury, and patent IPRs
- Intellectual property development and research, competitive patent analysis.
- Rotorcraft vibration reduction using active material treatments and integrated on-blade actuation technology for Bell Helicopter (Variable Geometry Advanced Rotor Technology program)
- Crashworthy aircraft seat design using shape memory materials and rotorcraft occupant restraint systems for NASA and Air Force

More information at http://www.starboardinnovations.com

Midé Technology Corporation, ***Senior Engineer***
Cambridge, Massachusetts
November 1998-February 2000
Active in technology, product, and business development.

- Co-developer, PowerAct™, a novel piezoceramic actuator/sensor
- Principal Investigator for Air Force-funded research program to develop advanced rotor concepts and team lead for Bell Helicopter Dynamically-Tailored Airframe Structures program

The MIT Active Materials and Structures Laboratory, ***Research Assistant***
Cambridge, Massachusetts
May 1995-October 1998

- Project leader for design, manufacture, and hover testing of a Mach-scale active helicopter rotor blade for individual blade control of vibrations and noise
- Developed manufacturing process for and characterized active fiber composite piezoelectric actuators
- Teamed with Boeing as part of Smart Structures for Rotorcraft Consortium
- Aided in design and led implementation of Mach-scaled rotor test stand facility

The MIT Space Engineering Research Center, ***Research Assistant***
Cambridge, Massachusetts
January 1993-May 1995

- Developed a Rayleigh-Ritz model of a composite plate with embedded, anisotropic active materials and acoustic radiation

- Designed, manufactured, and tested adaptive composite plates with active plies

Duke University Department of Mechanical Engineering, *Laboratory Assistant*
Durham, North Carolina
May 1992-December 1992

- Fabricated and tested a fiberglass wind-tunnel model for measuring airfoil pressure distribution with LabView data acquisition system virtual instrument shell

NASA Langley Research Center, Configuration Aeroelasticity Branch, *Intern*
Hampton, Virginia
June 1991-August 1991

- Performed aerothermoelastic analysis of a NASP vertical tail using a finite element model

PROFESSIONAL ACTIVITIES

Licensed Professional Engineer (PE) in mechanical engineering in TX, ND, CT

American Society of Mechanical Engineers (ASME), Associate Member, PE Review Instructor

Society of Petroleum Engineers (SPE), Member

American Institute of Aeronautics and Astronautics (AIAA), Member

PUBLICATIONS

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A. Lengyel and J. Rodgers, "Energy Absorbing Technology for Crashworthy Seats", 61st AHS Annual Forum, Grapevine, TX, June 2005.

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10337299 – Perforating apparatus and method having internal load path

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10151152 – Perforating gun connectors

10138718 – Perforation crack designator

9909408 - Protection of electronic devices used with perforating guns

9909384 - Multi-actuating plugging device

9598940 - Perforation gun string energy propagation management system and methods

9447678 - Protection of electronic devices used with perforating guns (8978817*)

9091152 - Perforating gun with internal shock mitigation

9051812 - Through tubing bridge plug and installation method for same

9019798 - Acoustic reception

8985200 - Sensing shock during well perforating

8978817 - Protection of electronic devices used with perforating guns

8978749 - Perforation gun string energy propagation management with tuned mass damper

8893801 - Method and apparatus for pressure-actuated tool connection and disconnection

8881816 - Shock load mitigation in a downhole perforating tool assem. 8714252*,8714251*)

8714270 - Anchor assembly and method for anchoring a downhole tool

8555959 - Compression assembly and method for actuating downhole packing elements

8490686 - Coupler compliance tuning for mitigating shock produced by well per. (8393393*)

8408286 - Perforating string with longitudinal shock de-coupler (8397800*)

8397814 - Perforating string with bending shock de-coupler

7781939 - Thermal expansion matching for acoustic telemetry system (7557492*)

7594434 - Downhole tool system and method for use of same

7595737 - Shear coupled acoustic telemetry system

7363967 - Downhole tool with navigation system

7325605 - Flexible piezoelectric for downhole sensing, actuation and health mon (7234519*)

7322416 - Methods of servicing a well bore using self-activating downhole tool

7246660 - Borehole discontinuities for enhanced power generation

*Denotes patents with same title

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Cudd. Testified at hearing in September 2016 and trial in 2020. Reference Pearce Durick LLP and Sutter Law. 2016-2020.

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TOTAL SEPARATION SOLUTIONS, LLC, v. F. ALAN "BUD" FRICK, BUTLER & COOK, INC. d/b/a/ BUTLER AND COOK, INC, d/b/a B & C OF FORT SMITH, INC., JOHN J. "TOBY" KOPROVIC, AND HYDROS, INC. d/b/a/ HYDROS d/b/a/ HYDROS AMERICA in the DISTRICT COURT of HARRIS COUNTY, TEXAS, 215th JUDICIAL DISTRICT. Served as expert for plaintiff, including deposition and trial testimony. Reference Fulkerson Lotz LLP, 2007-2009.